Creation of a Diagnostic Tool for Medical Decisions and Research

(Technical Paper)

The Ethical Analysis of Introducing Artificial Intelligence into Healthcare

(STS Paper)

A Thesis Prospectus Submitted to the

Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements of the Degree
Bachelor of Science, School of Engineering

Michael M. Hughes
Fall 2019

Technical Project Team Members
Michael Hughes
Jessica Mahoney
Elnaz Ghajar-Rahimi

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Approved by Prof. Jason Papin, Department of Biomedical Engineering

Approved by Prof. Kent Wayland, Department of Engineering & Society

General Research Problem: Ensuring Highest Quality Standard of Patient Care

How can diagnostic software improve quality of care for patients and efficiency of physicians?

According to Dr. Joshua Eby of the Infectious Diseases department at the University of Virginia, providing the highest quality patient care is the top priority of every physician (personal communication, October 22, 2019). That means understanding the copious amounts of data surrounding every patient in order to tailor care to fit their specific needs. Data collection and analysis are clearly a vital part in the healthcare system. Keeping accurate patient records and being able to access them easily allows for medical professionals to make the most informed decisions. Currently, the medical professionals at the UVA hospital spend large amounts of time sifting through patient data in varying formats across several systems. This creates inefficiencies and makes it more difficult for them to make decisions on a patient case. The current problem that is to be addressed through technical design and sociotechnical research is how outcomes for patients in the healthcare system can be improved through better organization, storage, and use of patient data.

Creation of Infectious Diseases Data Analysis Program (IDDAP) to Supplement Electronic Health Record Systems

How can a computational diagnostic tool provide medical professionals with patient data in a meaningful way in order to help them make more informed decisions?

The frequency of clinical trials, the sheer number of patients worldwide, and the interconnected structure of treatment plans significantly increase the magnitude of patient data files. Currently, in the hospital at UVA, data from numerous patient files are stored on several systems. The unique nature of each patient makes manually matching past and present patient cases extremely difficult and time consuming. Unfortunately, the current data-mining software platform being used, EPIC, is cumbersome with a layout that makes sorting through a large number of patient files difficult and inefficient. Although 85% of large hospitals use the Electronic Privacy Information Center, the EPIC platform is unorganized, non-intuitive, and limited in its data-mining functionalities. ("Epic, Cerner control 85% of large hospital EHR space, KLAS reports," n.d.). There are several critical gaps in the application of Electronic Health Record (EHR) platforms when collecting data. Critics explain that patient files are either individually accessed in EPIC or compiled into an excel file, and, thus, EHRs increase workload and catalyze physician burnout (Arndt et al. 2017). When medical professionals are attempting to access patient files for a specific field they must sift through the data by hand as the varying formats across the system makes the data difficult to filter. On average clinicians spend two hours on EHR tasks per hour of face-to-face patient contact, accumulating to nearly more than one-half of their work day (Arndt et al. 2017). A rapid filtering of past and present patient data

via a computational tool will help doctors and researchers make more informed decisions, help them modify their current practices to improve standards of care, and reduce workload.

We aim to develop an interface for doctors in the UVA medical system to easily access past patient data. This project attempts to provide clinicians in the infectious diseases department with a software program that will eliminate the gap between data stored in EPIC or excel sheets and the analysis desired by the physician.

In order to accomplish this goal, the team will utilize Rshiny, an R studio package for creating standalone or interactive web apps, to develop The Infectious Disease Data Analysis Program (IDDAP). This will allow the program to be easily installed across all computers and will allow doctors to tailor the medical diagnostic tool to their desired specifications.

This technical project will be completed in a team of three biomedical engineering undergraduates alongside Dr. Jason Papin, and PhD candidate, Laura Dunphy. The group will interview clinicians in the UVA Department of Infectious Diseases and employees in the Department of Quality and Performance Improvement in the Fall 2019 semester to determine the criteria for an efficacious computational medical diagnostic tool. The computational medical diagnostic tool will be developed after the interviews and continued throughout the Spring 2020 semester.

At the completion of the project the team hopes to provide a fleshed-out software that medical professionals can use to access, sort, and analyze patient data. This would allow clinicians to make more informed research decisions and hopefully shift current quality improvement research towards providing clinicians with appropriate measures for analyzing critical data.

Ethical Analysis of autonomous diagnosis programs in healthcare

Can artificial intelligence be used as a patient diagnosis program, while maintaining ethical integrity?

Introduction

Stephen Hawking, one of history's most influential scientists, once said "[Artificial Intelligence] is likely to be either the best or worst thing to happen to humanity." So, with the development of such an advanced technology how do we ensure that "the computers have goals aligned with ours" (Stephan Hawking, Zeitgeist 2015 conference, London). Perhaps even more difficult than creating the actual technology itself will be debating the ethical dilemmas that are co-developed. This is a necessary step in the creating of artificial intelligence in order to determine if this new technology will help or hurt humanity in the end. This thesis studies the ethics surrounding artificial intelligence to find out effects autonomous programs have on users in order to understand how these programs could be integrated into the healthcare system.

Artificial intelligence (AI) has a present and growing impact in society today. In the world of self-driving cars, pizza delivering robots, and entire assembly lines run by algorithms, the age of autonomy is upon us. More and more, humans are taking a step back from roles that would be done more efficiently by a computer program or an AI. Introducing an AI or computer program that could diagnose patients would change the entire landscape of the doctor's offices. The research question posed seeks to determine if present day artificial intelligence has the ethical bearing to be implemented into the healthcare landscape.

Framework for Ethical Analysis

High quality patient care is the top priority of medical professionals everywhere. The Hippocratic Oath echoes this through several lines that emphasize patient centered care and the need for cognizant decisions regarding the patient's wellbeing (Miles, 2005). Specifically, a problem with current practices is misdiagnosis. Diagnostic errors are estimated to occur in 3-5% of medical imaging cases constituting 75% of medical malpractice cases (Lee, Nagy, Weaver, & Newman-Toker, 2013). Of these diagnostic errors, approximately 75% were due to 'cognitive factors' including: anchoring bias (being stuck on an initial impression), framing bias, availability bias, satisfaction of search, and premature closure (Dilsizian & Siegel, 2013; Graber, Franklin, & Gordon, 2005). These biases are something an artificial intelligence or software would not encounter. The Hippocratic Oath also acknowledges that "there is art to medicine,… and that warmth, sympathy, and understanding may outweigh…" even the most accurate programs that drastically improve diagnostic outcomes ("Medical Definition of Hippocratic Oath," n.d.; Miles, 2005). A large portion of high-quality patient care is human interaction. In their most desperate times, patients find comfort in interactions with their favorite nurse or a calming physician. By implementing an AI in healthcare for diagnostic purposes, many patient-doctor interactions would be cut out and thus lower the quality of care in the eyes of many patients. On the other hand, in some scenarios it would give physicians more time to deal with the more difficult patient cases. They would be able to pass the simpler cases to the diagnostic program freeing up more time for them to interact with patients who require the most attention.

Here, both medical professionals and patients are invested in this proposed research project. Physicians want to create a more efficient environment in order to care for more patients as well as provide a better standard of care for patients, which AI could potentially accomplish. Patients become invested when their standard of care is changed. Whether the standard will be improved, by increased efficiency for example, or potentially worsened, such as by eliminating doctor-patient interaction, is under question. This thesis will address these and as well as the other necessary questions to understand if AI are ethically appropriate for the doctor's offices or if physicians are a critical part of every patients care.

Currently, there is no clear consensus in the field as to the ideal theory to better understand the ethical concerns pertaining to the use of intelligent healthcare agents (Anderson & Anderson, 2008). Ideally, the agents would always act in the best interest of the patient,

contain sympathy and compassion, make the patient feel comfortable, etc. All the things a human physician could do without any of the biases or errors. To create such an agent, the developer of the agent must understand several aspects of ethical theory. The agent must fully align with data protection requirements, minimize or eliminate the effects of bias, as well as understand the effects each decision will have on the quality of patient care (Vayena, Blasimme, & Cohen, 2018). However, this utopian scenario is not something we see in society, so the ethical analysis of these agents falls to projects such as this.

The two schools of thought that will be used to explore the research question are: utilitarianism and deontological (duty) ethics. These two ethical theories in several ways contradict each other when applied to the research question. Utilitarianism would posit that which ever action provides the most total good would be the correct decision (Driver, 2014). Deontological ethics, on the other hand, would only mark a decision as correct is if it were morally right, regardless of the overall consequence (Alexander & Moore, 2007). These two theories contrast each other well for this research question because it seems to put the well-being of society as a whole against the well-being of each individual, an issue that introducing AI into healthcare may introduce. Utilitarianism may say it is ethical to implement a diagnostic program to increase the total number of patients diagnosed, while duty ethics might say it is not ethical because the quality of an individual patient's care might be reduced by eliminating the doctor-patient relationship and thus violating the moral norm.

Presented here are two sides to the coin that is understanding the ethics of introducing AI into the health space. The overall goal is to improve the quality of patient care and well-being and the research proposed here would weigh the merit of each of these theories in order to add to the conversation regarding the ethical standing of AI in the world of healthcare.

Data Collection and Analysis

In order to investigate the research question and perform an ethical analysis, this thesis will compare the technology under question with analogous case studies as well as previous technologies throughout history that parallel the development of AI.

The use of case studies will allow the researchers to extract detail from analogous scenarios and apply them to the ethical analysis of AI in healthcare. Case studies will be selected based on the similarity of the case to that of healthcare, the date in which the case occurred, as well as other important factors such as the ethical theory being used. For example, data may be collected on specific cases of autonomous programs in self-driving vehicles where a specific instance of a lapse in the program occurred and the ethics of the program was under question. The case will be analyzed by finding a utilitarian or deontological analysis of such a case. The proposed research would use the utilitarian or deontological analyses of others in parallel scenarios to gain a knowledge on how such theories could be applied to the ethics of artificial intelligence in healthcare. The analysis of case studies would help to address several issues. Currently, AI is being evaluated for accuracy, structure of reasoning, and the efficiency with

which conclusions are reached is of importance (Chandrasekaran, 1983). Evaluating these aspects in similar cases would show the "thought process" of the machine. It is important to understand the way in which a machine "thinks" in order to understand how the AI may get to a decision and if it is using ethically appropriate means to get there. Analyzing the way in which the program reaches a decision would then allow for researchers to determine if the program is using an ethical pathway to obtain a diagnosis and evaluate the ethical nature of such a program in the healthcare system.

Using technological parallels in society and throughout history will allow researchers to understand how AI and other autonomous diagnostic programs can be analyzed using the two ethical theories present in this thesis.

Understanding the Ethics of AI

At the completion of the research this thesis hopes to provide a better understanding of the ethical standing current artificial intelligence has in the healthcare industry. The knowledge will provide both patients and medical professionals with information on if this technology should be utilized and how patient's quality of care may be affected and the landscape of doctor's offices might be disrupted if this technology were to be implemented.

Overall Conclusion

Data have been collected and studied for centuries in order to better influence decisions. People have always used analyzed trends and studied history in order to better understand how to solve the world's problems. In healthcare, both those problems and the data collected are the patients themselves. Clinicians use data on past patients to treat problems current patients face. With the enormous amounts of data that surround every patient, that analysis is not always easy for medical professionals. Presented here, this thesis will explore how medical diagnostic programs can make that analysis easier for clinicians and if artificial intelligence has the ethical bearing to completely automate that process. This information will help physicians and patients understand how their environments might eb altered by the introduction of these technologies and if they would even like them to be introduced. Additionally, one could build on this research to tailor new technologies to address the pitfalls of new technologies in the healthcare space with the overall goal of always providing the highest quality of patient care possible.

References

Alexander, L., & Moore, M. (2007). *Deontological Ethics*. Retrieved from https://stanford.library.sydney.edu.au/archives/win2015/entries/ethics-deontological/#PatCenDeoThe

Anderson, M., & Anderson, S. L. (2008). Ethical Healthcare Agents. In M. Sordo, S. Vaidya, & L. C. Jain (Eds.), *Advanced Computational Intelligence Paradigms in Healthcare—3* (Vol. 107, pp. 233–257). https://doi.org/10.1007/978-3-540-77662-8_10

Chandrasekaran, B. (1983). On Evaluating Artifical Intelligence Systems for Medical Diagnosis. *AI Magazine*, *4*(2), 34.

Dilsizian, S. E., & Siegel, E. L. (2013). Artificial Intelligence in Medicine and Cardiac Imaging: Harnessing Big Data and Advanced Computing to Provide Personalized Medical Diagnosis and Treatment. *Current Cardiology Reports*, *16*(1), 441. https://doi.org/10.1007/s11886-013-0441-8

Driver, J. (2014). The History of Utilitarianism. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy* (Winter 2014). Retrieved from https://plato.stanford.edu/archives/win2014/entries/utilitarianism-history/

Epic, Cerner control 85% of large hospital EHR space, KLAS reports. (n.d.). Retrieved October 23, 2019, from Healthcare Dive website: https://www.healthcaredive.com/news/epic-cerner-control-85-of-large-hospital-ehr-space-klas-reports/553906/

Graber, M. L., Franklin, N., & Gordon, R. (2005). Diagnostic Error in Internal Medicine. *Archives of Internal Medicine*, *165*(13), 1493–1499. https://doi.org/10.1001/archinte.165.13.1493

Lee, C. S., Nagy, P. G., Weaver, S. J., & Newman-Toker, D. E. (2013). Cognitive and System Factors Contributing to Diagnostic Errors in Radiology. *American Journal of Roentgenology*, *201*(3), 611–617. https://doi.org/10.2214/AJR.12.10375

Medical Definition of Hippocratic Oath. (n.d.). Retrieved October 29, 2019, from MedicineNet website: https://www.medicinenet.com/script/main/art.asp?articlekey=20909

Miles, S. H. (2005). *The Hippocratic Oath and the Ethics of Medicine*. Oxford University Press, USA.

Vayena, E., Blasimme, A., & Cohen, I. G. (2018). Machine learning in medicine: Addressing ethical challenges. *PLOS Medicine*, *15*(11), e1002689. https://doi.org/10.1371/journal.pmed.1002689